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CLINICAL COMMENTARY

PHYSICAL THERAPY MANAGEMENT OF ICE HOCKEY ATHLETES: FROM THE RINK TO THE CLINIC AND BACK

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ABSTRACT

Background: The increasing number of athletes playing hockey compels rehabilitation professionals working in orthopedic and sports settings to understand the unique functional demands of ice hockey and the patterns of injuries they may promote.

Purpose: The purpose of this clinical perspective is to: (1) discuss the functional implications of different positions and age levels on injury prevalence within the sport; (2) summarize the seven most common injuries sustained by ice hockey athletes; and (3) present a conceptual model for the clinical management and prevention of these injuries by rehabilitation professionals.

Methods: A narrative review and synthesis was conducted of currently available literature on prevalence, etiology, rehabilitative intervention, prognosis, and prevention of ice hockey injuries.

Results: Research evidence is available to support the prevalence of injuries sustained while participating in ice hockey, as well as the most effective clinical treatment protocols to treat them. Most of the existing protocols are based on clinical and sports experience with incorporation of scientific data.

Conclusion: This clinical commentary reviews the current concepts of ice hockey injury care and prevention, based on scientific information regarding the incidence, mechanism, rehabilitation protocols, prognosis, and prevention of injuries. Science-based, patient-centered reasoning is integral to provide the highest quality of rehabilitative and preventative care for ice hockey athletes by physical therapists.

Key Words: Closed-head injuries, femoro-acetabular impingement, high ankle sprain injuries, ice hockey injuries, MCL injuries, shoulder injuries.

Level of Evidence: 5

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INTRODUCTION

Ice hockey in the United States is an increasingly popular competitive sport, with participants ranging from youth players to professional athletes. Between 1990 and 2010, the number of athletes participating in all levels of ice hockey grew 143% in the United States.[1] In 2013, 510,279 athletes were registered with USA Hockey, which is the national governing body for ice hockey athletes in the United States.[1] Growing participation in ice hockey at all levels may lead to higher incidence of injuries sustained during practices and competitions than in the past. These injuries sustained on the ice, in turn, may increase the number of ice hockey injuries seen in general orthopedic and sports rehabilitation settings.

Ice hockey is unique in that it is a collision sport that requires participants to skate a narrow contact surface (blade) with a low friction surface (ice) while moving in all planes of motion. Injuries to the head, shoulder, hip, knee, and ankle and foot are most common, and their mechanisms of injury are unique to the sport.[2] The increasing number of athletes playing hockey compels rehabilitation professionals working in orthopedic and sports settings to understand the unique functional demands of ice hockey and the patterns of injury they promote. Conceptual work that addresses the prevalence and mechanism of injuries specific to ice hockey is integral to providing the highest quality of care for hockey athletes. Further, rehabilitation protocols, prognosis and prevention of hockey injuries are essential pieces to provide uniform expectations regarding identification of at-risk but uninjured athletes, health/injury status, and anticipated return to play for injured athletes. The purpose of this clinical commentary are to: (1) discuss the functional implications of different positions and age levels on injury prevalence within the sport; (2) summarize the seven most common injuries sustained by ice hockey athletes; and (3) present a conceptual model for the clinical management and prevention of these injuries by rehabilitation professionals.

SPORT-SPECIFIC FUNCTIONAL REQUIREMENTS OF ICE HOCKEY

Ice hockey athletes have requirements for strength, speed, flexibility, and endurance that are unique to the sport and vary between positions. Three forwards, two defensemen, and one goaltender are on the ice at a given time for each team at full strength (not including shorthanded or powerplay scenarios); all of these positions have varying functional demands. For example, defensemen skate backward more often than they skate forward, and vice versa for forwards (Figure 1). However, both forwards and

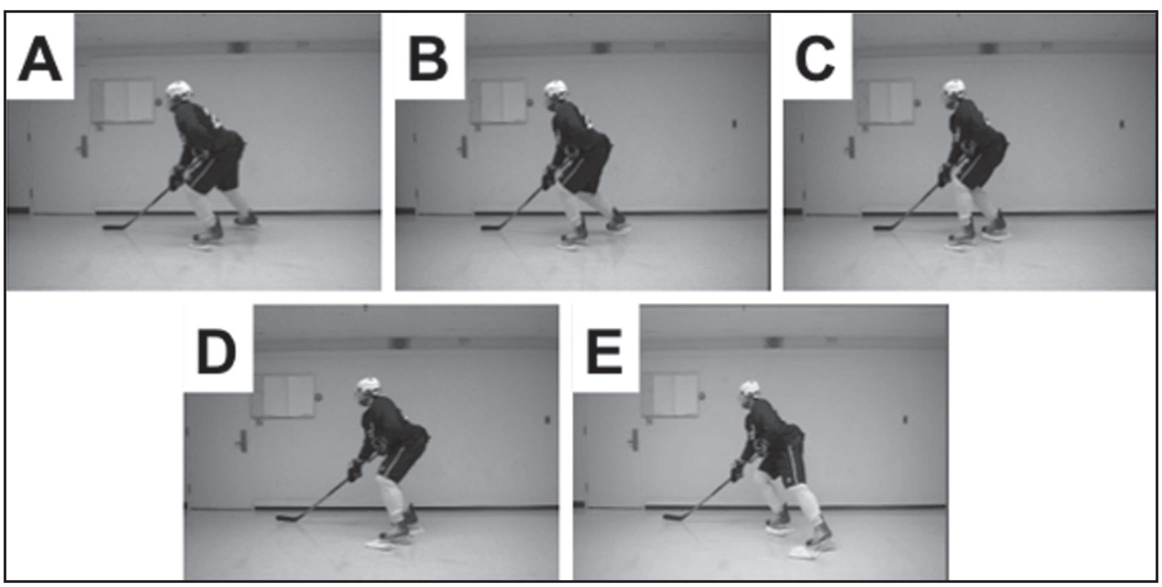

Figure 1. Backward ice hockey skating. *[Alternating legs backward stride. Offensive or defensive players will skate backwards during a game to play defense against an opposing team. A. left stance leg, right leg starting a "C" cut. B. left stance leg, right leg continuing "C" cut. C. left stance leg, right leg finishing "C" cut. D. right stance leg, left leg starting a "C" cut. E. right stance leg, left leg finishing a "C" cut back to starting position.]*

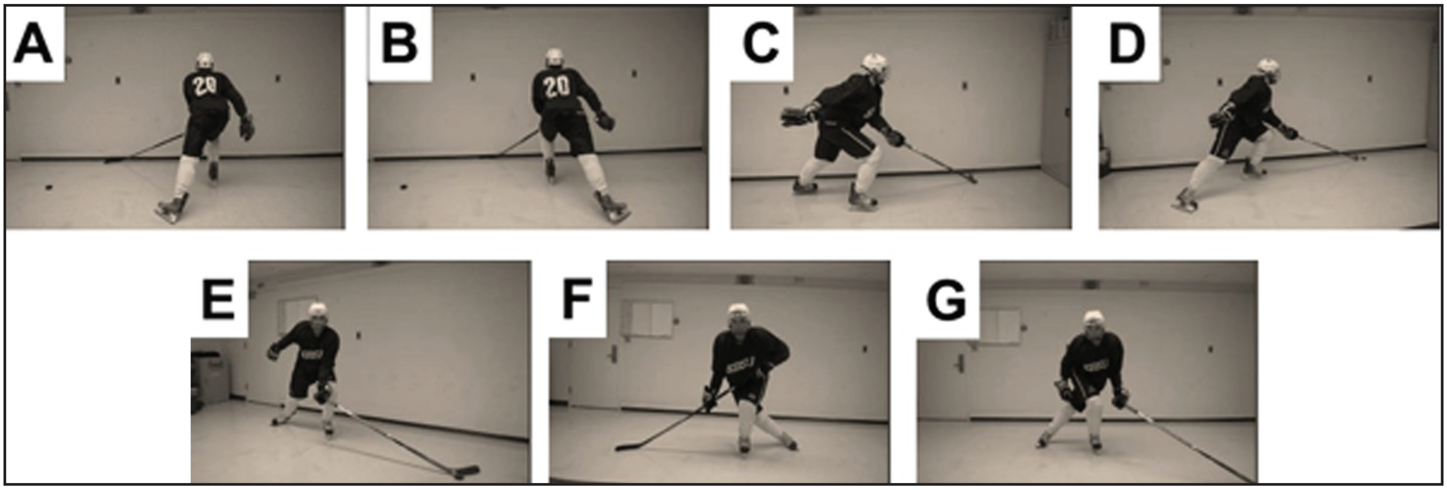

Figure 2. Forward ice hockey skating and crossover. *[Alternating forward stride in A-E. Forwards and defensemen will skate forward during a game when their team has possession of the puck on the offensive attack. F-G shows cross-overs, which forwards or defensemen will perform when a quick change of direction is needed.]*

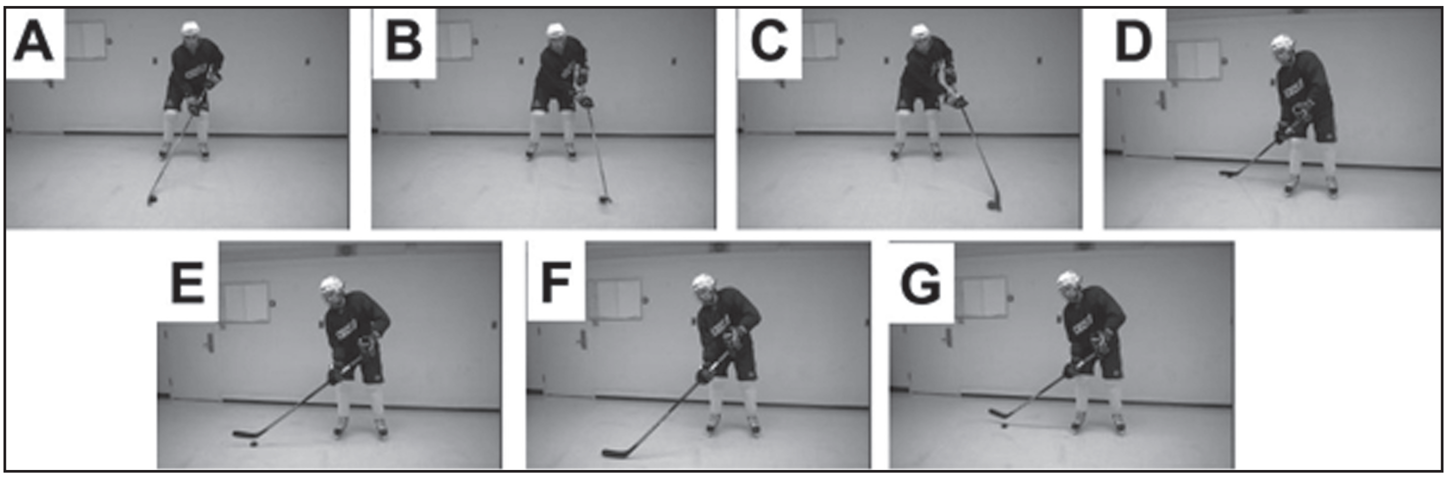

Figure 3. Stickhandling. *[Defensemen and forwards will stickhandle the puck when they have offensive possession and are trying to maintain that possession during a game. A. starting position, keeping the puck within a players feet for control. B-C. stickhandle to the backhand, or non-dominant side, to keep puck away from an opposing player. D-G. stickhandle to the forehand, or dominant side, to keep puck away from an opposing player.]*

defensemen are required to skate forward and cross-over (Figure 2). These movement patterns predispose ice hockey athletes to various types of injuries. For example, skating backwards and forwards in the sagittal plane require completely different muscle contractions. The push-off stride in forward ice hockey skating requires hip extension, hip abduction, knee extension and ankle plantarflexion. The muscular contractions necessary to achieve this action include concentric hip extension, concentric hip abduction, concentric knee extension and concentric ankle plantarflexion. Additionally, isometric contractions of medial and lateral ankle stabilizers, and eccentric contraction of the hip adductors provide transference of force from the skate blade to the center of mass. The return to start motion requires hip flexion and adduction, knee flexion, and ankle dorsiflexion. Furthermore, stickhandling the puck to maintain possession requires hand-eye coordination, strength, endurance, and proprioception (Figure 3). Forwards are required to take face-offs after each stoppage of play, which call for flexibility, strength, stability, considerable balance, and proprioception (Figure 4). There are a variety of types of shots that can be taken during a hockey game, such as the wrist shot for accuracy (Figure 5), the

Figure 4. Faceoffs positioning. *Faceoffs occur after each whistle stoppage during a game. Faceoffs are instrumental in initiating and maintaining possession of the puck. A. starting position before puck is dropped. B. stick hits ice just after puck is dropped by referee. C. faceoff is won backwards to start team's possession of the puck after a whistle stoppage.*

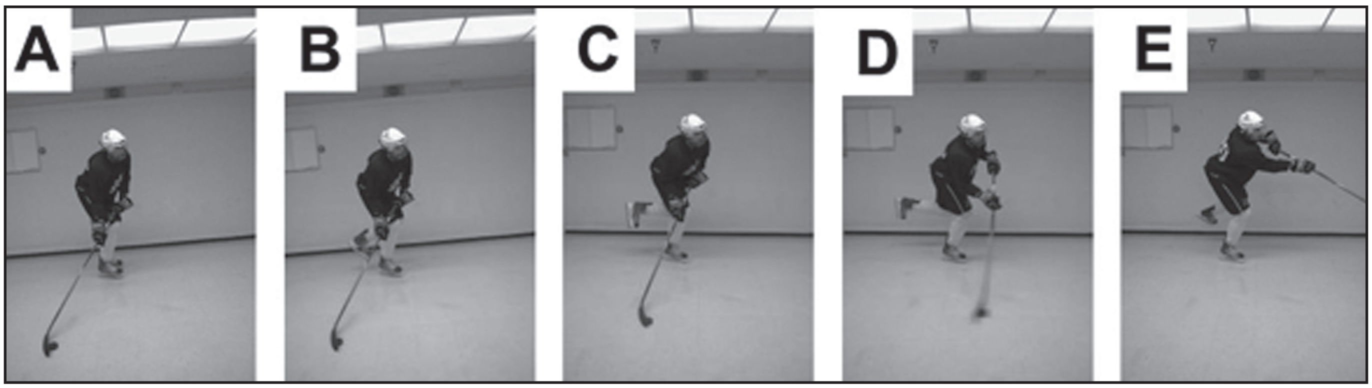

Figure 5. Wrist shot. *Wrist shots are used when accuracy and quickness of the release are necessary. A. player's head is up, looking at target to shoot with wrist shot. B-D. wrist shot is taken. E. following through, with stick pointed towards target for accuracy.*

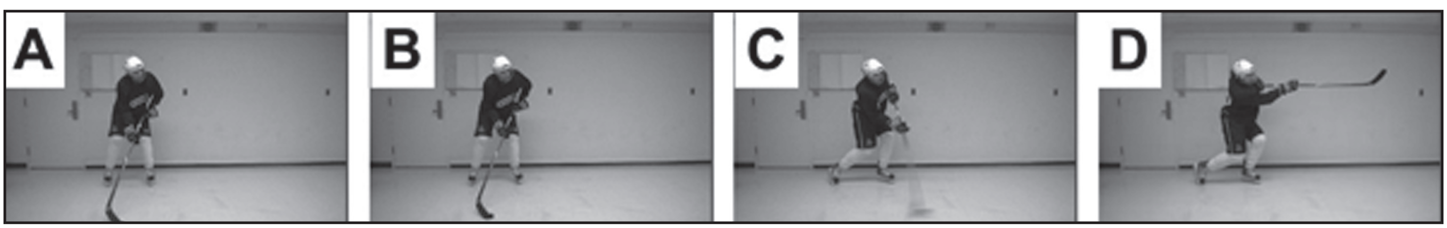

Figure 6. Snap shot. *Snap shots are used when the shot needs to be executed as quickly as possible, with more velocity than a wrist shot. A. player's head is up, looking at target to shot with snap shot. B-C snap shot is taken. D. following through, with stick pointed towards target for accuracy.*

snap shot for quickness (Figure 6), and the slapshot for power and velocity (Figure 7). Goaltenders have periods of time with no action that can quickly change to periods of rapid-fire shots, requiring mental focus and quick reactions. Goaltenders must be flexible enough, especially in their lower extremities, to reach across the crease (goal mouth) to make a save if needed, while maintaining the strength and endurance to stay upright as long as shots are coming at them from the opposing team.

Recent evidence suggests important similarities between the strides of forward skating in ice hockey and speed-skating athletes.[3] These similarities may have implications for sport-specific ice hockey training. Van Ingen et al[3] describe the energy-system and power requirements for speed-skating athletes. For example, Van Ingen et al[3] describes how speed skaters require a high breakdown rate of energy-rich phosphates in the first 4-5 seconds of the skating burst. This is imperative for ice hockey players as

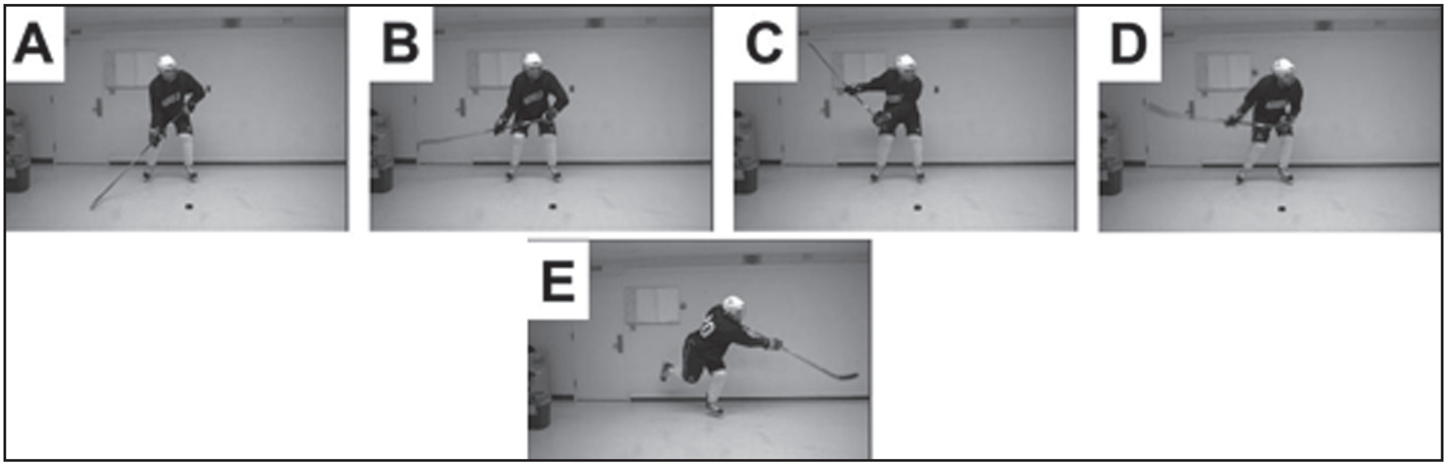

Figure 7. Slap shot. *Slap shots are used when velocity and power are needed for a shot. Slap shots can produce the most velocity, but are more difficult to control the accuracy. A. player's head is up, looking at target to shoot with slap shot. B-D. slap shot is taken. E. following through, with stick pointed towards target for accuracy.*

well. Players who effectively accelerate in the first few strides may have a higher percentage of winning the race to the puck and gaining puck possession, which is integral for a team's success. The results of Van Ingren et al[3] suggest skaters improve their first push off by initiating a start technique that allows a more horizontally-directed propulsive force. This acceleration technique and explosive power for ice hockey athletes is key for their off-ice power training programs in order to initiate their stride at the highest velocity possible. Emphasizing a positive shin angle, which is when the knee is forward of the ankle, with skating form and utilizing harness resistance drills can be very beneficial approaches to improving acceleration. Rehabilitation professionals should utilize plyometric exercises that emphasize horizontally directed propulsive forces when athletes are towards the end of their rehabilitation stages and are preparing for return to participation. Plyometric and short-burst drills can improve the athlete's acceleration and affect the rapid acceleration tasks required to win individual competitions for the puck throughout the course of a game.[4]

EPIDEMIOLOGY OF ICE HOCKEY INJURIES

Ice hockey is a contact sport in which athletes may be at elevated risk for types of injury that require time away from practice and competitions.[5] Engebretsen et al[6] concluded that the risk of sustaining an injury was highest for ice hockey athletes compared to all registered athletes from other sports in the 2010 Olympics. According to Tuominen et al,[7] the second period of games had the highest percentage of injury in players of any position, including forwards, defensemen, and goaltenders. These results indicate that proper endurance training of ice hockey athletes is imperative to not only improve their performance, but also reduce the risk of injury. Engebretsen et al[6] also found that up to one-third of registered ice hockey participants sustained some type of injury during the study period that required time away from practice or competition. Engebretsen et al[6] also found that ice hockey had the highest incidence of athlete-to-athlete trauma among all Olympic sports.

According to Agel et al,[5] the percentage of injuries that occur during collegiate ice hockey games comprises 13.5% knee injuries, 8.9% acromioclavicular (AC) joint injuries, 6.2% upper leg contusions, and 4.5% pelvis and hip muscle strains. Emery et al[8] studied 986 minor hockey players, aged 9-17 years old. The authors of this study concluded that 45% of all injuries occurred during body checking, with concussions, shoulder sprain/dislocation, and knee sprain as the most common injuries.[8] The epidemiological analysis previously described will form the structure for conditions reviewed in this clinical commentary.

CARE AND MANAGEMENT OF SELECTED ICE HOCKEY INJURIES

The following sections of this clinical commentary will review the identification and rehabilitation management of typical injuries sustained during hockey play. The injuries will include closed head injuries, injuries to the shoulder complex, hip, knee, and foot and ankle. The underlying sport-specific biomechanical predisposition for each injury will be discussed, along with unique rehabilitation considerations that relate to the functional requirements of the sport.

Closed head injuries

McCrory et al[9] defines concussion as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Clinically recognizable signs and symptoms of a concussion include headache, confusion, amnesia, dizziness, nausea, and fatigue. Deits and colleagues[10] found the incidence of concussions is three-fold greater in ice hockey athletes aged 2-18 years (9%) compared to those older than 18 years (3%). These results may imply that novice and younger athletes are at elevated risk. It is notable that these estimates may be biased by several factors, including but not limited to competitive pressures, social perception, and team stigma that could promote under-reporting in older athletes. Johnson et al[11] studied hockey players aged 16-21 years old and found that 17 of 67 (25.3%) sustained a concussion during a single season, with five of those players also suffering a second concussion. The results of this study indicated a rate of concussion seven times higher than the highest rate previously reported in literature. According to a prospective study performed by Echlin et al,[12] 8.47 in 1000 collegiate ice hockey athletes, including both men and women, sustained a concussion during a hockey season. Concussions at high levels of competition have important economic consequences. In the National Hockey League (NHL), 10% of concussions resulted in time loss of 10 days or greater, equating to roughly 11 games missed per occurrence.[13] In the NHL, injuries represent a total salary cost of about $218 million dollars (USD) per year, with concussions making up about 20% of that total salary lost, accounting for 42.8 million USD.

The most common mechanism of injury for concussions in ice hockey is when the temporal side of the head is struck by another players' body part or object.[14] Wennberg et al[15] concluded that the incidence of concussions in ice hockey is greater in forwards than defenseman and goaltenders. The authors of this review believe that a possible explanation for the increased risk for forwards is that these players commonly skate with the puck as compared to players in other positions, and therefore are more likely to be body-checked by an opposing player. In contrast, defenders commonly face the flow of play for the majority of action, while forwards spend a greater amount of time playing in a 360 degree field of play, moving forward to receive passes or crossing the ice in a lateral direction at high speed

Optimal management of concussions in ice hockey athletes begins with accurate recognition and diagnosis, which can be complicated by symptom under-reporting by parents and athletes.[16] Improved awareness of concussions needs to occur in all levels of hockey. Rehabilitation professionals' outreach activities should be oriented toward the youth ice hockey population, which is the largest and also most at risk for concussions.[10] Appropriate recognition and management of concussions needs to be explained to younger athletes and those around them to ensure their safety as the number one priority. Epidemiological studies of concussions in ice hockey have incorporated the use of formal pre-participation baseline cognitive and psychomotor testing, such as the Sport Concussion Assessment Tool 2 (SCAT2) and Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) in order to determine a baseline for each athlete and aid in the diagnosis of a concussion when a closed head injury is sustained.[16] Szabo et al concluded that there is a need for further information about the ImPACT validity indices and whether they truly reflect poor effort, or if there is a learning effect present.[17] The authors of this commentary suggest that pre-participation screening should occur at all competitive levels of ice hockey.

Treatment protocols for concussions vary in different organizations; so average time out of the game for concussion may vary greatly between skill levels and age groups for both patient-specific and protocol-specific reasons. The return to play timeline is and needs to be longer for youth athletes after sustaining mTBI. The National Hockey League requires a five step return-to-play protocol in order for an athlete to return to full participation after

Table 1. *Gradual return-to-play protocol after a concussion.*[12]

Rehabilitation Stage	Function Exercise at Each Stage	Objectives of Each Stage
1. No activity	Symptom-limited physical and cognitive rest	Recovery of injured brain
2. Light aerobic exercise	Walking, swimming, or stationary cycle, keeping intensity <70% of maximum permitted heart rate; no resistance training	Increase heart rate, without increased symptoms
3. Sport-specific training	Skating drills for ice hockey, no head-impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, for example, passing drills in ice hockey; may start progressive resistance training	Exercise, coordination and cognitive load
5. Full contact practice	After medical clearance, participation in normal training activities	Restore confidence and assessment of functional skills by coaching staff
6. Return to play	Normal game play	Discharge

sustaining a concussion (Table 1).[9] This system is controversial, however, with the early days of the protocol including full physical and cognitive rest. It has been suggested that active rest/reduced cognitive and physical activity may be better. Alsalaheen and colleagues[19] studied the effectiveness of vestibular rehabilitation to reduce dizziness and improve gait and balance in a number of athletes, including ice hockey participants, who had sustained a concussion. In this study, the role of vestibular rehabilitation is emphasized to ensure player is safe with regard to gaze stabilization prior to return to play. The authors of this study concluded that vestibular rehabilitation should be considered in management of individuals post-concussion who experience dizziness with activity, as well as balance dysfunction that are not resolved with rest. Further research should be conducted in the area of physical therapy management of closed head injuries to examine the role of the physical therapist, including but not limited to: graded exercise therapy and monitoring of symptoms with aerobic activity.

Shoulder complex injuries

Shoulder complex injuries – consisting of those that occur at glenohumeral joint, acromioclavicular joint, and corresponding soft tissue structures – make up 18% of all ice hockey injuries.[8] Approximately three-quarters of shoulder complex injuries result from contact with another athlete, most commonly as a result of body-checking.[19] According to Donaldson et al,[13] shoulder injuries account for a total of $306,600 USD in salary loss per season in the NHL. The growing prevalence of contact with body checking at younger ages in ice hockey increases the athletes' risk of sustaining a shoulder injury.

Glenohumeral joint injuries

Glenohumeral joint (GHJ) subluxation and dislocation occurs in approximately 8% of elite Swedish ice hockey athletes, aged 18-26.[20] Anterior dislocations and subluxations occur most often when the shoulder is forced posteriorly from contact with another player or a directly blow to a shoulder that is abducted and externally rotated, causing anterior displacement. An injury to the GHJ could occur to any forward, defenseman, or goaltender who may come into contact with another player. The presence of GHJ subluxation or dislocation may be confirmed the external rotation apprehension special test.[21] The prognosis for return to play from glenohumeral joint injury depends on the severity of the damage to the supporting structures of the GHJ. Skating is often contraindicated with GHJ injuries until near end phase of rehabilitation due to the possibility of unanticipated falls. Dryland training is an ideal alternative, where a rehabilitation professional may be of high priority. Rehab professionals should utilize high level therapeutic exercise to improve strength, power, and endurance. Sport-specific exercises to include stick handling, shooting, and skating may be instrumental in progressing the athlete back to their sport as quickly as possible.

Acromioclavicular joint injuries

Another shoulder pathology that is common among hockey athletes is acromioclavicular joint (ACJ) sprain. ACJ injuries commonly occur when an individual lands directly on the ACJ or when the athletes' shoulder is checked shoulder-first into the boards. An important prevention strategy that can be used to help with prevention and return-to-play treatment of ACJ injuries is the use of a protective foam pad used under the athlete's shoulder pads to attenuate impact and protect the injured ACJ in the event of another body check mechanism. ACJ conditions can be ruled out or confirmed with clinical special tests, such as the ACJ compression and cross-over tests. The Bell van-Riet test consists of cross-body adduction by the patient as well as attempted elevation against resistance (SN 98%) and can be used as a clinical special test when ACJ involvement is suspected.[22]

Prevention of shoulder complex injuries

Sprague and colleagues[23] found that the Functional Movement Screen (FMS™) shoulder mobility test can be used to supplement shoulder range of motion, thoracic spine mobility, motor control, soft tissue mobility, and muscle imbalance assessments as a more comprehensive screening tool for injury prevention measures. Global shoulder and rotator cuff strengthening programs should be implemented in all training programs for ice hockey participants as a pre-habilitation technique in order to decrease the prevalence of shoulder complex injuries. [24] Findings from the shoulder mobility section of the FMS™ can provide rehabilitation professionals with a more specific route than isolated muscle strength and range of motion testing from which to direct the rest of their examination. This allows the rest of the examination and evaluation to be more specific when performing range of motion and strength assessments, as well as any special tests. During pre-participation physicals, rehabilitation professionals should include functional screening tools, range of motion and strength testing, and obtain a detailed medical history of any previous shoulder problems in order to note athletes who may be at elevated risk for sustaining a shoulder complex injury.

Hip injuries

The hip, thigh, and groin is the location of approximately 10% of all ice hockey injuries.[8] Femoroacetabular impingement (FAI) and adductor strains are two of the most common health conditions in ice hockey athletes that involve this joint.[8]

Femoroacetabular impingement

FAI is most common in goaltenders, especially those who play the "butterfly-style" position as they are constantly moving into and out of position of hip flexion and internal rotation (Figure 8). Philippon et al observed 28 ice hockey players who received hip arthroscopy on one hip to treat FAI and labral damage.[25] Participant age ranged from 18-36 years old, with all radiographs showing evidence of cam impingement, and 85% of the images showing mixed cam and pincer impingement.[25] The authors of this study concluded that professional ice hockey players with FAI can return post-operatively to skating and their prior level of participation at the professional level. Further, the study highlighted the importance

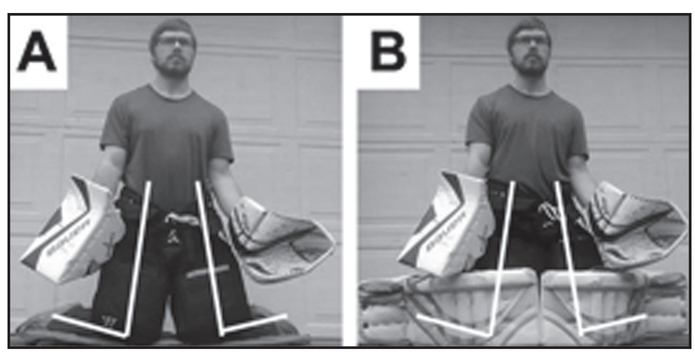

Figure 8. Butterfly position for goaltenders. *Goaltenders are often in this butterfly position, without pads (A) and with pads (B). This position of prolonged hip internal rotation may place these goaltenders at higher risk for hip pathology than other positions within ice hockey.*

Table 2. *Phases and timelines for the standard rehabilitation protocol following arthroscopic hip surgery without microfracture for FAI and labral tears, and the one-ice supplemental rehabilitation program designed for ice hockey goaltenders.*[15]

Rehabilitation Phase	Goals	Precautions/Restrictions	Treatment Strategies
Phase 1 (Weeks 1-10)	1. Protection 2. Decrease inflammation 3. Early ROM 4. Prevent muscle inhibition 5. Education	1. Limit external rotation and extension 2. Weight-bearing restrictions for 4 weeks	1. Continuous passive motion 2. Stationary bike 3. Circumduction 4. Massage 5. Isometrics 6. Pool therapy 7. Ice
Phase 2 (Weeks 4-12)	1. Normalize gait 2. Restore full ROM 3. Neuromuscular control	1. Avoid muscle irritation, especially hip flexors 2. Avoid overloading the joint	1. Wean from crutches 2. Weight bearing stability exercises
On-Ice Phase 1 (Week 4)	1. Normalize skating		
On-Ice Phase 2 (Week 5)	1. Normalize skating with pads		
On-Ice Phase 3 (Weeks 7-10)	1. Light goalie-specific movements		
On-Ice Phase 4 (Weeks 10-12)	1. Crease work without butterfly (speed)		
On-Ice Phase 5 (Week 13-on)	1. Crease work with butterfly (explosive movements)		
Phase 3 (Weeks 5-13)	1. Restore endurance strength 2. Optimize neuromuscular control 3. Restore cardiovascular fitness	1. Overloading the joint	1. Double- to single-leg strength **Pass Vail Hip Sports Test
Phase 4 (Weeks 13-on)	1. Restore power and strength 2. Return to play		1. Power and conditioning

of early recognition of the signs and symptoms of FAI by the athletes and health care professionals. It is imperative to do so in order to seek treatment as early as possible, in order optimize prognosis.[25] Special tests that can be used to confirm the presence of FAI include the flexion-abduction-external rotation (FABER) and flexion-adduction-internal rotation (FADIR) tests. According a study performed by Philippon et al, the sensitivity of the FABER test is .71 with a specificity of 1.0 and found that 97% of patients with labral impingement were (+) on the test.[26]

Pierce et al[27] described a functional post-surgical rehabilitation program for FAI in ice hockey goaltenders that could also be applied to other on-ice positions. The protocol suggests on-ice return to sport-specific drills four months post-operatively, with a return to competition shortly thereafter.[27] The program is divided into a four-phase rehabilitation protocol plus six phases of on-ice training (Table 2). Return to participation is determined when the injured athlete obtains successful pass of a score higher than 17/20 on the Vail Hip Sports Test without reported increase in symptoms, such as pain or swelling, during the on-ice drills. The Vail Hip Sports Test incorporates a series of dynamic multiplanar functional activities against the resistance of a Sportcord™ (Baton Rouge, LA). This test is composed of four components that include single-leg squat for three minutes, lateral bounding for 90 seconds, and forward/backward jogging for two minutes each. The patient is graded based on the ability to demonstrate strength and muscular endurance, absorb and produce force, all while maintaining appropriate movement quality at the trunk and lower extremity.[28] Non-surgical cases of FAI may be managed in similar fashion, with the timeline adapted to the player's phase of tissue healing and symptom-limited abilities. Treatment of FAI is unique to the individual's position and age, with goaltenders needing more flexibility and forwards/defenseman having to concentrate more on strengthening.

Adductor muscle strains

Adductor strains are common in ice hockey players because of the unique skating stride that occurs while playing and training. Chaudhari and colleagues describe that large, eccentric contractions of the adductor muscle group are known to result in or exacerbate adductor strain injuries.[29] Therefore, the constant eccentric and concentric loading of the adductor muscle group during a forward skating stride lead to strain on the contractile tissue, which may lead to injury. Clinical evaluation and examination should include the hip adductor group manual muscle testing, as well as alignment checks of the pelvis and sacrum. The prognosis for adductor strains depends heavily on the patient's previous injury history as well as the severity of the muscle strain/tear. Intervention for hip adductor muscle strains should begin with restoring hip mobility and soft tissue extensibility. Hip muscle and thoraco-lumbo-pelvic complex strengthening should accompany acute phase interventions for adductor strains, including adaptation to a player's stride by improving hip abductor and external rotator activation. Improving deep core stabilization, which includes activation of the transversus abdominus and the pelvic floor musculature, can help distribute the mechanical stresses placed on the adductor muscles during a stride.[29] Hip and lumbopelvic motor control development also plays a key role in rehabilitation of adductor muscle strains. Not only do ice hockey athletes need femur-on-acetabular range of motion and control, but they also need proper neuromuscular control of closed-chain acetabular-on-femur motion at the hip joint. For example, improved strength, range of motion, and motor control available for a particular athlete after going through rehabilitation for an adductor strain could provide a more mechanically advantageous stride that may offload injured tissues.

It is imperative for rehabilitation professionals to work on both ends of the injury spectrum, including prevention of the initial injury and rehabilitation post-injury, when the hip in involved with injuries to ice hockey athletes. The use of functional screening tools, stride assessment, as well as a detailed medical history pertaining to previously sustained hip injuries are instrumental in providing these athletes with the best chance to participate without being reinjured. Prevention, early detection, and following proper treatment protocols is important for rehabilitation professionals to provide the highest level of care for ice hockey athletes with hip adductor muscle strains.

Knee injuries

Fifteen percent of all ice hockey injuries in minor hockey occur at the knee joint,[6] with medial collateral ligament (MCL) sprains accounting for 44 per 10,000 ice hockey athlete-hours.[30] The high incidence of this injury largely is due to the on-ice collisions that produce excessive valgus force at the knee. Forwards are most likely to sustain this injury, since they are typically skating forward and can be body checked below their center of mass, creating a valgus load at the knee and injuring the medial knee structures.[30] The MCL valgus stress test is a special test that should be utilized to confirm or rule out an MCL sprain in the clinic. Aronson et al found that the tibiofemoral joint should be fully extended or flexed to 5 degrees to assess all resisting medial tibiofemoral joint structures (including the anterior cruciate ligament) and again at 15 to 20 degrees of flexion to further assess the MCL.[31] The prognosis for returning to competition from isolated MCL injuries depends heavily on the athlete's adherence to his or her rehabilitation protocol and the severity of the injury. The participant can usually return between zero and two weeks after a Grade I injury and between two to four weeks after a Grade II injury.[32] The prognosis for a Grade III MCL injury is generally six to eight weeks before return to full ice hockey competition. Appropriate rehabilitation of the MCL after injury is essential to restore the ability to tolerate the push-off and cross over motions required during skating.

A well-guided treatment program is essential following MCL injury. Acute phase interventions are important following injury, with compression particularly effective to decrease knee edema.[32] Rehabilitation for MCL injuries should place emphasis upon open chain progressing to closed chain hip abductor strengthening starting in the sagittal plane and progressing to the other planes of motion, in order to decrease the risk of valgus load being placed on the knee joint. Improvements of lateral hip rotation range of motion decreases valgus knee stresses with load and should be included in any rehabilitation program to the MCL. Active knee range of motion exercises, including cycling and active range of motion, can prevent loss of range of motion that may occur from disuse. Following MCL injury, ice hockey athletes should maintain year-round quadriceps and hamstring strengthening and continued hip, oblique, and core strengthening exercises in order to decrease the amount of time lost and decrease the risk of re-injury. Marchant et al suggests using an unlocked hinged knee brace during the early stages of treatment and during return to sport, and discontinue its use after the competitive season is over. [32] Athletes who sustain a severe MCL tear (i.e. isolated Grade III injuries) may require reconstructive surgery. Effective skating at a competitive level is impractical if not impossible without an MCL to stabilize the medial knee during the skating motion. Chronic valgus instability or rotatory instability are two of the most important issues that need to be addressed when it comes post-reconstructive treatment interventions.[32] These instabilities should also be checked at pre-operative initial evaluation in order to maximize rehabilitation efforts. Exercises to improve lower extremity proprioception, hip, trunk, and pelvis stability and neuromuscular control, and knee motor function are key to an athlete's prognosis to return to play following reconstructive surgery of the MCL.

Figure 9. Hockey skate photo. *Typical ice hockey skate worn on the right foot shows that it covers approximately ¼ of the lower leg.*

An important aspect of MCL injuries sustained by ice hockey athletes is the prevention of these injuries from occurring. Pre-season functional screens, including single-leg stance and squat screen, hip mobility and pelvic alignment assessments, muscle-length testing such as the Thomas and Ober's tests, and postural analysis should be performed by healthcare professionals to note which players may be more susceptible to an injury to the MCL.[33] Rehabilitation professionals should observe for and address any increased valgus loading during a squat or static genu valgum which may put stress on the MCL without an external force being applied. The Landing Error Scoring System can be used as a screening tool to detect valgus along with single limb drop landings.[32] Best clinical practices should encompass pre-season assessments, as well as monthly in-season and post-season monitoring to address the functional demands of the ice hockey participants and work to decrease risk of MCL injury.

Foot and ankle injuries

Lower leg injuries are relatively infrequent in ice hockey, accounting for only about 6% of injuries.[8] Ice hockey players wear skates that encase the entire foot and ankle complex; the typical ice hockey skate runs approximately one quarter of the way up the lower leg, which provides more lateral foot and ankle stability seen during other cutting and collision sports (Figure 9). Thus, lateral ankle sprains associated with an inversion mechanism are far less common in ice hockey players than high ankle sprains. Conversely, non-goalie skates position the ankle in a 5-10 degree dorsiflexed position in order to aid in the skating stride by holding the center of mass forward. As high ankle sprains occur with forced dorsiflexion and eversion, the position of the skate along increases the risk for this type of injury. The most common injury to the lower leg sustained by ice hockey athletes involves the distal tibiofibular syndesmotic complex (i.e. "high ankle sprain"). Syndesmotic injuries occur when the talus is forced into excessive abduction with the talocrural joint positioned in extreme dorsiflexion, in the man-

Table 3. *Three-phase rehabilitation program for tibiofibular syndesmotic injury.*[21]

Rehabilitation Stage	**Goals**	**Sample Treatments**	**Criteria for Progression**
Acute	Joint protection while minimizing pain, inflammation, weakness, and loss of motion	1. *Joint protection:* immobilization in a walking cast, boost, custom orthosis, lace-up ankle brace, or ankle stirrup. External rotation and end range dorsiflexion are avoided 2. *Weightbearing:* based on assessment and patient symptoms – varies from nonweightbearing to full weightbearing 3. *Pain and inflammation control:* compression, elevation, cryotherapy, electrical stimulation, manual therapy, other modalities, and/or alternative therapies such as acupuncture 4. *Maintenance of strength and mobility:* gentle motion, cycle ergometer, progressive resistance exercise with bands, cords, ankle weights, and/or electrical stimulation	Able to ambulate in full weightbearing on various surfaces and traverse stairs with minimal discomfort
Subacute	Normalize joint mobility, strength, neuromuscular control, and return to basic function in activities of daily living	1. *Mobility:* low-load, long-duration stretching with cords, bands, or towels; repetitive motion through the range of motion; cycle ergometer; joint mobilization; and/or aquatic therapy 2. *Strengthening:* cords, bands, ankle weights, heel raises, step up/down, calf press with isotonic equipment, and/or neuromuscular training exercises 3. *Neuromuscular training:* progressive use of air cushions, rocker boards, wobble boards, air-filled domes, trampolines, or other perturbation of support surfaces	Can jog and hop with minimal discomfort
Advanced Training	Prepare for return to sports participation	1. *Neuromuscular training:* perturbation of support surfaces 2. *Functional/agility drills:* running, jumping rope, hopping, shuffling, carioca, and/or figure-8 running with or without use of props such as cones, hurdles, and ladders 3. *Strength/power:* advanced strengthening, plyometrics 4. *Sports-specific drills:* dribbiling drills, running reception patterns, shooting balls, skating/rollerblading	*Return to sports when:* Performs sport tasks at game speed with minimal discomfort and quality movement

ner of a pronation-abduction mechanism.[34] Clinical tests that may be used to rule out or confirm a high ankle sprain include direct palpation to the site of injury, the tibiofibular squeeze test, external rotation stress or Kleiger's test, and the fibula translation test.[35] If a high ankle sprain is suspected, plain film radiographs should be taken if possible to rule out lower leg and foot fractures, which can present with similar symptoms.

The prognosis for high ankle sprains in ice hockey athletes is difficult to predict due to the nature of the sport. According to Laprade et al,[36] syndesmotic injuries could take up to 12 weeks to heal in ice hockey athletes. Williams et al[34] advocates a three-stage rehabilitation approach for tibiofibular syndesmotic injuries (Table 3). The acute phase includes immobilization, protected weight bearing, and control of the inflammatory.[34] The sub-acute phase is related to healing, and the goals are to regain normal forefoot and rearfoot mobility, and introduce strengthening and neuromuscular control activities.[34] The third and final stage involves advanced training and game-like situations on the ice. More aggressive training exercises and hockey-specific activities should be implemented in this stage to get the player ready for game speed.[34] Returning to play after sustaining a syndesmotic injury should only occur when appropriate proprioception, or recognition of joint location in space, as well as neuromuscular control of the foot in all three planes of motion are demonstrated by the athlete during both advanced training exercises and on the ice.

CONCLUSION

This clinical commentary provided an overview of the seven most common injuries sustained by ice hockey athletes along with current, evidence-based treatment protocols for healthcare professionals to utilize when they work with one of these patients. Sport-specific injuries such as concussions, glenohumeral dislocations, acromioclavicular joint separations, FAI, adductor strains, MCL sprains, and syndesmotic injuries can be treated non-operatively and rehabilitation professionals should utilize their clinical skills and reasoning to properly address and rehabilitate these athletes back to their prior level of function, when appropriate. It is imperative for the rehabilitation professional to recognize, treat, and refer injuries based on a sound understanding of the unique functional requirements of the sport and its widening popularity. Further research should be performed to examine the most effective treatment protocols to provide the highest quality of care to these athletes and pre-season assessment tools to attempt prevention strategies.

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